Investigation of Flow Through a Power-Steering Flow-Control Valve

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205–544–1574

The complex flow-path intersections within today's power-steering pumps must be designed to minimize fluid aeration and cavitation since the noise and vibration that result not only affect the automobile's power-steering system performance, but also directly impact passenger comfort. At the same time, by design, the flow-control valve must regulate flow through the power-steering system across a wide range of engine speeds and steering maneuvers. Fluid-borne noise and cavitation at fluid pressures near 6,900 kiloPascals (1,000 pounds per square inch absolute) result from the extreme operating conditions that these power-steering flow-control valves experience. A simplified cross section of the flow-control valve in its open position (fig. 90) illustrates that the vented flow joins the flow from the steering system and "supercharges" it before entering the power-steering pump. The cavitating jet and the mixing of the two flows produce noise and reduce the quality of flow entering the pump. Delphi Saginaw Steering Systems builds thousands of flow-control valves a day, yet continues to evaluate each new design by building and testing each one individually. In response, MSFC has entered into a Space Act Agreement to transfer its experience gained in evaluating rocket engine components with experimental and computational techniques.

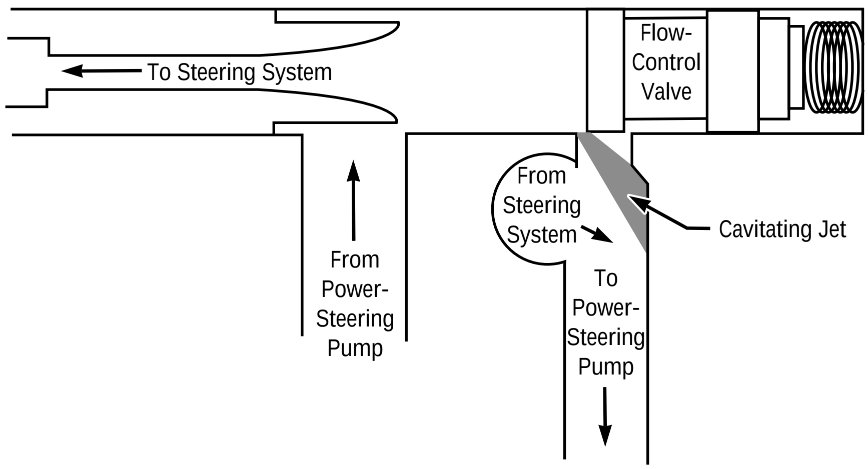

FIGURE 90.—Cross section of open flow-control valve.

MSFC will design a superscale acrylic model of a flow-control valve and test the model under simulated pump-operating conditions with water as the test fluid. With valve flow-path diameters on the order of 12.7 millimeters (0.5 inch), the scaled-up model reduces the operating pressures to a more manageable 104 kiloPascals (15 pounds per square inch absolute) and provides adequate room for measurement access and visual inspection of the flow. Detailed pressure, velocity, and turbulence intensity measurements and qualitative flow visualization in the superscale model will document the flow environment across the entire valve-operating envelope. A parallel effort will develop a computational fluid dynamic model of the flow-path geometry. This model will be calibrated with the experimental data. The resulting computational model will then be used to evaluate the performance of alternate flow-control valve designs, providing valuable predictions of cavitation incipience, flow separation, and system pressure losses. Finally, an optimized flow-path design derived from the baseline experimental test results and the computational fluid dynamics design optimization will be developed.

Industry Involvement: Delphi Saginaw Steering Systems